TEXTILE RESEARCH

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The Editor's Page

CO-OPERATORS in U. S. Institute's research on warp sizing and sizing materials have just received confidential progress report No. 6—"A Method for Studying the Distribution of Starch and Gelatin Sizes on Viscose." In addition to a description of the techniques employed, the report is illustrated with numerous photomicrographs of cross-sections of variously sized yarns. Some of the practical results of the method are discussed under the following headings: Effect of Viscosity of Size Mix; Comparison of Penetrating and Coating Effect of Starch and Gelatin in Sizes; Effect of Can-drying on Yarn Shape; Comparison of Behavior of Yarn of Same Denier but from Different Companies.

* * *

INTERPRETATION to the practical men of the industry, and also to students and executives, of the results and techniques of basic scientific research, is rendered extremely difficult because the scientist and the technician speak, in effect, different languages, or at least use different vocabularies. Yet the gap must be bridged in some manner if research results are to be adequately utilized, and if the potentialities of fundamental research are to be fully appreciated. Ultimately, textile as well as other of the large industrial plants will have their own scientists, who will not only be interpreters but practitioners of basic research. Meantime, we must rely upon the few men who have the ability to do this interpreting job. To interpret the fibre research upon which several of its Fellows have been employed the Textile Foundation has been fortunate to secure the services of Prof. E. R. Schwarz of M. I. T., and the first instalment of his interesting and instructive article appears in this issue. Upon completion it will be reprinted and made generally available.

* * *

U. S. I. Personals

Alban Eavenson, vice-president, and member Board of Directors, Executive Committee and Research Council of U. S. Institute, has been elected to honorary membership in Phi Psi, the textile school fraternity.

Dr. E. H. Killheffer, first vice-president and chairman, Executive Committe of U. S. Institute, was a speaker at the annual banquet of Phi Psi at the Spring Mountain House, Schwenksville, Pa., April 17th.

W. E. Emley, chairman, Research Council of U. S. Institute, and Dr. H. DeW. Smith, vice-chairman, attended the international congress of the International Association for Testing Materials in London, Eng., April 19 to 24.

Dr. F. Bonnet, director technical service, Viscose Co., and member of the Administration Committee for U. S. Institute's drying research, ad-

dressed the New York Section of the A. A. T. C. C. recently on "Spun Rayon," with special reference to the use of synthetic resins in finishing.

Former U. S. Senator Jesse H. Metcalf, of the Wanskuck Co., Providence, R. I., has given Brown University $500,000 for the construction of a new chemical research laboratory and the endowment of its research program in chemistry.

Franklin W. Hobbs, president, Arlington Mills, Boston, Mass., was a representative of the employers' group for the domestic wool manufacturing industry at the International Textile Labor Conference in Washington, D. C., last month.

Ernest N. Hood, treasurer and director of U. S. Institute ever since its organization, and formerly treasurer of Naumkeag Steam Cotton Co., and other New England mills, is now treasurer and director of Old Colony Manufacturing Co., Taunton, Mass., he and two associates having acquired control of the company.

Franklin W. Hobbs was re-elected chairman, Stuart W. Cramer, treasurer, and E. T. Pickard, assistant treasurer and secretary of the Textile Foundation, at the annual meeting held in Washington, D. C., April 21st.

National Rayon Technical Conference

THE program of papers to be presented and discussed at the National Rayon Technical Conference, to be held at the Wardman Park Hotel, Washington, D. C., Friday and Saturday, May 14 and 15 under the auspices of the Textile Section of the American Society of Mechanical Engineers is as follows:

Friday A.M.:—Air Conditioning of Textile Plants Making and Using Rayon, by L. L. Lewis, Carrier Engineering Co.; Mechanics of Rayon Weaving, by Albert Palmer, Crompton & Knowles Loom Works.

Friday P.M.:—Cause of Rayon Crepe Variation with Special Reference to Throwing, by John Macia, Research Fellow of the American Association of Textile Chemists and Colorists and the Throwsters Research Institute; Effect of Embossing and Boil-off on Finished Crepe Fabrics, by James McGibbon, North American Rayon Corp.

Friday, 7 P.M., Informal Dinner:—Address, Color Comes of Age, by Howard Ketcham, Howard Ketcham, Inc. This will be followed by the Viscose Company's motion picture on rayon production and finishing.

Saturday A.M.:—Manufacture and Use of Rayon Staple Fibre, by Dr. F. Bonnet, The Viscose Co.; The History of Rayon in the Retail Field, by Ephraim Freedman, director, Macy's Bureau of Standards; Stainless Steels and Their Application in the Textile and Rayon Industries, by G. W. Hinkle, metallurgist, Republic Steel Co.

This will be an open conference and further details may be obtained by addressing M. A. Golrock, Jr., Sec., A. S. M. E. Textile Div., 29 West 39th St., New York, N. Y., or Secretary, U. S. Institute for Textile Research, Inc., 65 Franklin St., Boston, Mass.

Drying Study Co-operators Meet

Confer at Bureau of Standards as to Final Details of Program

CO–OPERATORS in U. S. Institute's research on textile drying conferred, April 15th, with the members of the administration committee for this study at a meeting in the Industrial Building of the National Bureau of Standards, Washington, D. C., where the research is to be conducted. As a result of suggestions of co-operators, the administration committee, at a later session, adopted a final program which is basically the same as that submitted by the organization committee. The question of whether or not there should be an advisory committee was left with the administration committee with full power to act, but it was the majority opinion of those present that representatives of the 50 co-operators, and all contributing members of U. S. Institute qualifying to receive the confidential progress reports of the study, could be relied upon by the administrators for advice, when and if needed.

Chairman G. E. Hopkins of the administration committtee reported that he and his associates, Dr. A. C. Walker and Dr. F. Bonnet, were considering several applicants for the directorship of the research, but that they hoped to interview additional candidates before making a final selection.

Director Lyman J. Briggs of the National Bureau of Standards had kindly made it possible for U. S. Institute to hold the conference and luncheon at the Bureau and to visit its various laboratories, and in a brief address of welcome he expressed gratification that he was to have the opportunity of co-operating with this group in the solution of their particular problems; also to have this evidence that industry appreciates the services made available by the Bureau's research associate plan.

After luncheon most of those present spent the greater part of the afternoon in visiting Bureau laboratories, personally conducted in groups by W. D. Appel, chief Textile Section, Dr. H. F. Schiefer and Dr. Milton Harris, the latter director at the Bureau of the A. A. T. C. C.'s study on the chemistry of wool. The various laboratories of the textile section, which occupy a large part of three floors of the Industrial Building, attracted chief interest. Two facts of vital importance to the drying research were disclosed: (1) that much of the special equipment that would be required was already available, and (2) that desirable laboratory space was ready for this study. The latter, it seems, had recently been made available by the removal of a lot of obsolete textile machinery to the Federal prison at Atlanta.

Co-operators Represented

In addition to representatives of the Bureau of Standards, and members of the administration committee previously mentioned, Dr. E. H. Kilheffer, executive vice-president, and C. H. Clark, secretary of U. S. Institute, were present at the conference, and also the following representatives of co-operators: Albert Allen, Foxboro Co., Foxboro, Mass.; A. G. Ashcroft, Alex. Smith & Sons Carpet Co., Yonkers, N. Y.; Dr. S. W. Brainard, Rayon Div., E. I. du Pont de Nemours & Co., Buffalo, N. Y.; A F. Brown, Delaware

Rayon Co., New Castle, Del.; Lucien Buck, Proctor & Schwartz, Inc., Philadelphia, Pa.; Franklin C. Dexter, Calco Chemical Co., Bound Brook, N. J.; Alban Eavenson, Eavenson & Levering Co., Camden, N. J.; S. W. Fletcher, J. O. Ross Engineering Corp., New York, N. Y.; Richard P. Hawkins, Brown Instrument Co., Philadelphia, Pa.; H. D. Learnard, Pacific Mills, Lawrence, Mass.; Rinaldo A. Lukens, Continental Mills, Inc., Philadelphia, Pa.; Robert E. Oberholtzer, James Lees & Sons Co., Norristown, Pa.; Dr. F. D. Pilgrim, Tennessee Eastman Corp., Kingsport, Tenn.; N. B. Richardson, Tubize Chatillon Corp., New York, N. Y.; J. D. Robertson, Mt. Hope Finishing Co., North Dighton, Mass.; W. W. Sibson, Jr., Philadelphia (Pa.) Drying Machinery Co.; Frank S. Ward, Taylor Instrument Co., Rochester, N. Y.; Raleigh Reece, American Bemberg Corp., Elizabethton, Tenn.

Progress of Merchandising Study of Textile Foundation and U. S. Institute

REPRESENTATIVES of leading textile trade associations met, April 24, at a luncheon arranged by the Committee on Economic Research of U. S. Institute for Textile Research, to hear a report of progress on the study of Production and Distribution Organization in the Textile Industries, now being conducted by the University of Pennsylvania, in co-operation with textile trade associations and the Committee on Economic Research. The report was made by members of the staff of the Industrial Research Department, which is carrying on the study under the direction of Dean Joseph H. Willits.

Dean Willits said that over 300 interviews had already been made with executives in textile and related industries, and that over 500 interviews would be made before the completion of the study. Despite the number of interviews, Dean Willits pointed out that the staff of the Industrial Research Department could not possibly call upon all the persons whom it would like to see because the study to be adequate had to start with fibre preparation and end with the retailing of finished merchandise.

Attention was called to the new concept of vertical organization being developed in the study. This is to the effect that greater vertical organization is really a matter of securing control over the flow of merchandise, and that such control may be had directly through ownership of merchandise or indirectly through branding or licensing. As an illustration, it was said that a producer of finished fabrics was employing a form of vertical organization whether he established his own clothing factory or sold his fabrics on a license basis.

It was announced that the published report of the study would feature the "pros" and "cons" of methods for vertically controlling the flow of merchandise, at each of the important market breaks in the flow of textile merchandise, namely, prepared fibre (tops, etc.) yarns, gray goods, finished textiles, wholesaling (piece goods or garments), etc. For example, it was said that there would be a thorough discussion of the advantages and disadvantages of trademarking piece goods used by the cutting trades from the standpoint of both the weaver or converter and of the garment manufacturer.

Textile Foundation's Educational Projects Discussed

PRACTICAL discussion of the relationship between textile schools and the industry they serve was one of the principal features of the semi-annual conference of textile school deans held under the auspices of the Textile Foundation at Grove Park Inn, Asheville, N. C., April 12 and 13. Frederick M. Feiker, who conducted the educational survey for the Foundation and who continues in an advisory capacity, presided at the meeting. Stuart W. Cramer, a director and the treasurer of the Foundation, was present and participated in the discussion. Franklin W. Hobbs, chairman of the Foundation, was unable to attend. This was the first of the series of semi-annual conferences he has missed. Edward T. Pickard, secretary of the Foundation, took an active part with Mr. Feiker in the direction of the meeting.

Speaking first for the school deans, President Chas. H. Eames of Lowell Textile Institute urged manufacturers to continue their interest in the educational institutions in the industry; to take graduates into their mills and follow their progress carefully; and to stimulate research in the schools by bringing their problems there and "exerting pressure" on members of the instructing staffs to carry on such research.

Mr. Cramer, speaking for the Foundation and the industry, stated that he was deeply interested in this educational movement as one of the most important the Foundation is sponsoring. He recognizes in this movement an opportunity for the adjustment of differences of opinion on educational procedure, and consequently for the development of a coordinated approach to the problems involved.

William M. McLaurine, secretary of the American Cotton Manufacturers Association, raised the question whether the schools were selecting their undergraduates carefully enough and, particularly, whether they were preparing their students to do certain specific jobs. "Don't graduate a student unless you and he have some idea where he is going from there," he advised. He also recommended particular attention to research and to the study of industrial relations. The latter problem, he said, is "a great complexity that has come very much alert and alive in the last few years; you can be as indifferent to it as you like, but it still stands there."

D. G. Woolf, editor of *Textile World*, lauded the textile school program as the most important movement sponsored by the Foundation. He pointed out that textile manufacturers are now seeking young executives and are willing to pay good salaries for them—an indication that there really is promise for those who now enter the profession of textile engineering through the textile schools. He also urged the development of teaching material on the subject of industrial relations. Replying to the latter suggestion, Dr. A. H. Williams of the Wharton School of the University of Pennsylvania pointed out that a section of the text on economics which has been developed under the sponsorship of the Foundation, deals with industrial relations and could be used as a basis for further treatment. Dr. Williams' presentation of these teaching materials on textile economics was another of the main features of the conference. They cover four subjects: Economics in general; management; marketing; and textile costing. Intensive consideration of the text on the latter subject occupied a good part of the meeting.

(Continued on P. 288.)

Textile Fibres in the Light of Modern Science*

By EDWARD R. SCHWARZ, F. T. I.†

A Textile Foundation Publication

". . . the executive today of an important industry involving a complex technique should himself understand research to a sufficient extent to speak the language and to mix freely and usefully with research workers. It is just as necessary, in my opinion, for the modern executive to understand the examination of fibres under polarized light as to know the mechanics of a spinning frame or be able to read a balance sheet. Of course he cannot hope to know all the underlying optics, any more than he would attempt to operate personally any and all of the machines in his plants, or keep up with all of the intricacies of present day cost accounting systems; but he can understand those things which are important to his business, and this is now one of them."

DR. VANNEVAR BUSH
(*Textile Research*)

Introduction

ALL textile materials are composed of fibres. Nothing can be more fundamental, therefore, to the constitution of yarn and fabric than fibre. Thus the properties of fibres cannot fail to influence the properties of the ultimate products and the manufacturing processes involved in their creation. This fact is regularly recognized by the manufacturer who selects a particular fibre for a particular purpose, while he nevertheless may not have appreciated the fact that the real reason why wool, for example, produces so many varieties of satisfactory and unique finishes is because of its unique architecture. The wool fibre is built up by nature from building blocks or atoms (as the chemist calls them) of carbon, oxygen, hydrogen, and nitrogen, which are arranged just as definitely in a pattern as characteristic as

* An "inside story" in simple terms of the physicist's attack on the problems of fibre structure.

† Associate Professor of Textile Engineering, in charge of Textile Research, Mass. Institute of Technology, Cambridge, Mass.

is the structure of a cathedral. The cathedral could not be mistaken for a textile mill, although it is made up of just the same materials.

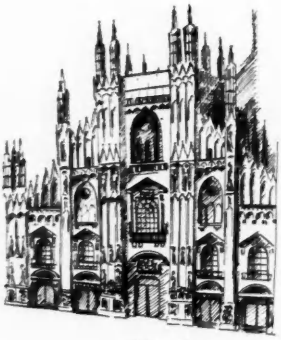


FIG. 1a.

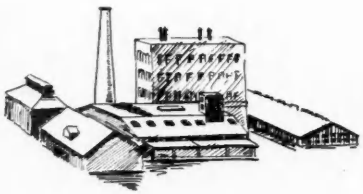


FIG. 1b.

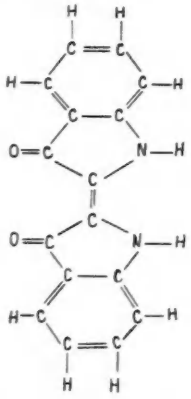


FIG. 2a. Molecular Structure of Indigo.

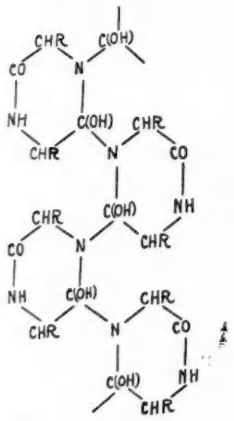


FIG. 2b. Molecular Structure of Wool. Both have the same atoms —but not the same arrangement.

Wool is made up of the same kind of atoms as is silk, but neither fibre would be mistaken for the other. The same selection of atoms found in wool is also found in feathers, in tortoise

shell, in horn and in indigo. Thus the dye itself may be made up of exactly the same kinds of atoms as the the fibres which it colors. The obvious difference between these substances is, after all, frequently a matter of arrangement of the atoms rather than their nature. The scientist may not know why the sheep is clothed in wool rather than in feathers or shell, but he is well on the way to explaining certain of the important peculiarities of the structure of these substances.

Anything he can learn about the ultimate construction of fibres should be of interest to the mill man. Certain of his discoveries *are* of considerable importance to the textile manufacturer; the great difficulty being that the scientist describes his findings in his own language. This language is too often not understandable to the layman. Thus many scientific facts are not appreciated nor applied by the textile manufacturer. Further, the methods used by the scientists as well as the instruments employed are not generally understood. It is hoped that the following pages may help to make the situation clearer.

One of the points which must be clarified at the start is the matter of relative magnitudes. The largest thing with which we shall be directly concerned is the fibre (a unit of fabric structure). The smallest is the electron (a unit of the structure of the atom). While few analogies are perfect, even a crude one may be of great help. Hence, no apology will be made for the comparisons which will be used.

Obviously, it would be impossible to cover the work which has been accomplished in the field of textile technology over the last twenty-five years in a single treatment of any reasonable length. Therefore, the present discussion is concerned with recent research undertaken by several holders of Textile Foundation Fellowships dealing with fibre structure.

Structural Similarity of Yarns, Fibers and Fibrils

There is an intresting parallel between the structure of fibres and the structure of yarns. This has been pointed out before, particularly (and forcefully) by Astbury in his "Fundamentals of Fibre Structure." Many natural fibres are fundamentally made up of long but exceedingly fine strands called

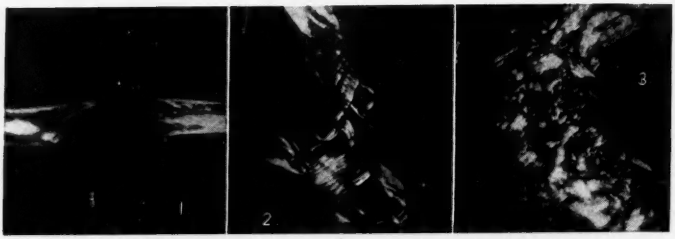


FIG. 3. Fibrils are made up of long-chain molecules, just as yarns are made up of fibres. Polarized light and a microscope show this structure.

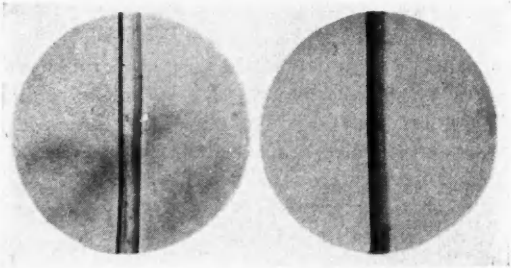


FIG. 4. Silk Filament Rayon Yarn

The arrangement of the fibrils of the silk filament is strikingly similar to the arrangement of the rayon filaments in a rayon yarn.

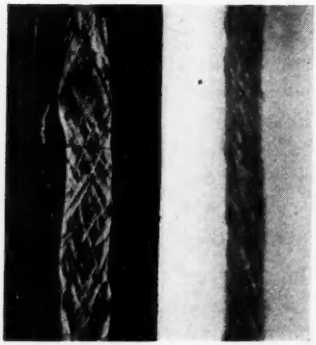


FIG. 5. A B

(A) Fibrils in cotton fibre. (B) Fibres in cotton yarn. The similarity of structure is apparent.

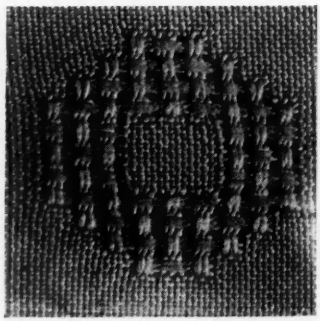


FIG. 6. A fabric contains many hundreds of yarns definitely arranged in the fabric structure.

fibrils. Sometimes, as in silk, these fibrils are arranged in substantially parallel order and closely parallel with the fibre axis. This arrangement, of course, is similar to that found in thrown silk or rayon yarns where very little if any twist is used to hold the filaments together. The fact that the fibrils are many times longer than they are wide or thick increases the similarity still more. In such a fibre as cotton, these fibrils are actually twisted in very much the same fashion as an ordinary cotton yarn. And even as fibres are distinguishable to the eye in a cotton yarn, so are these fibrils visible through the microscope.

The comparison may be extended one stage further, if we consider the similarity of the structure of the individual cotton fibre to the structure of the fibril. The fibre structure is impossible to see clearly with the unaided eye, but it is readily discernible through the microscope. The fibril structure is quite invisible under the microscope but may be studied in other ways. The structural detail of the fibril consists of molecules arranged in long chains so small, in spite of their length, that only by means of x-rays can certain of their characteristics be studied.

Extremes of Textile Fineness

At this point a consideration of the relative sizes of the structural units mentioned will be of interest. The usual yarn varies in diameter from a few hundredths to a few thousandths of an inch. A fabric which contains one hundred yarns or more to the inch is considered fine. A yarn containing one hundred or more fibres is a frequent construction. A single fibre often contains many hundreds of fibrils. All of these magnitudes are easily comprehensible, but the picture changes sharply when we consider the molecular chains which compose the fibrils, for here it is quite usual to have the smallest microscopically visible fibril contain more than one hundred thousand chains. Just how many molecules are contained in the length of one of the longest of these chains is still a matter of speculation. It is probably a matter of hundreds. Thus, if we were to start counting the molecules in an average wool fibre at the rate of one per second, eight hours per day, every day in the year, it would take at least *thirty million years* to complete the task.

We have, then, literally millions of millions of atoms clustered into molecules, which are arranged in chains (more firmly linked than any anchor chain ever built) which are in turn placed side by side and end on end to form the fibrils. These fibrils join to make up the fibres. Fibres are combined to form yarns, and yarns are the basis of most textile materials.

Textile Technologist as Interpreter

On the one hand the textile manufacturer is striving better to understand the properties of the fibres and yarns which he handles daily. On the other, the modern physicist and chemist unite to determine the structure and properties of the atom. And in all this, modern physics and chemistry are already throwing light upon problems of immediate interest to the textile technologist. He it is who must make such information available to the textile manufacturer in practical form. Just such investigations as will be described concerning the atomic and molecular structure of fibres are almost certain to determine the future of the rayon industry (for instance) as well as that of the finishing of woolens and worsteds.

A Strange and Useful Property of Textile Fibres

One investigator studies all the facts about fibres which his microscope and its accessories can show him. He discovers that all textile fibres have the strange property of polarizing light. He sees that the light which normally vibrated in many random directions to the direction of its travel, vibrates in only two directions at right angles with each other after passage through a rayon, wool, silk, flax or cotton fibre. To him it is at once apparent that it is only logical that this particular form of light (polarized light) should be used to further investigate fibre structure. He sends such light through a fibre and observes what happens, and a whole new field of research opens up.

Fibre Identification:—The results of the initial research efforts with polarized light have had three important applications already. The first is the use of this technique for the identification of fibres; particularly those of cellulosic nature. While fibres such as flax and hemp can be distinguished from cotton

rather readily, it is still difficult, if not impossible, to separate flax, hemps, jute and other bast and leaf fibres by ordinary

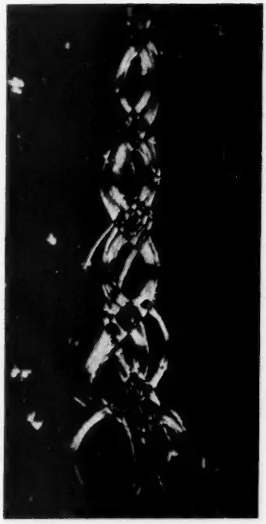


FIG. 7. A fibre contains many hundreds of fibrils (as in the jute fibre above) arranged definitely in the fibre structure.

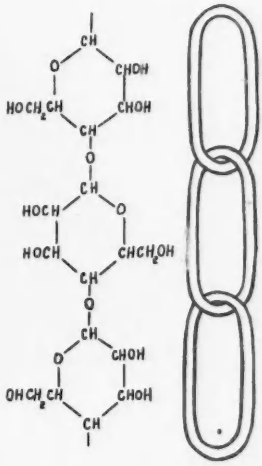


FIG. 8. Cellulose (the base structure of vegetable fibres) is made up of long chains of molecules.

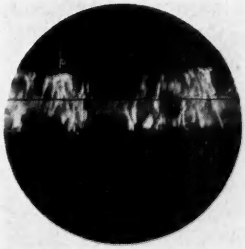


FIG. 9a. Ramie fibre as seen through the microscope in polarized light. This fibre (as are all textile fibres) is a polarizer of light.

methods. Many of these fibres are structurally different from each other when it comes to the arrangement of the molecules

and the "density of packing" of their ultimate "building blocks." The quantity known as the "specific index of birefringence" makes possible numerical measurement of these differences. This index is a measure of the degree of double refraction which the fibre shows and this, in turn, is closely related to the invisible fibre structure. It is directly measurable only by means of polarized light and the polarization microscope.

As an example of its usefulness, a series of values may be noted. (See Table I.)

TABLE I

Fibre	Specific Index
Acetate rayon	0.006
Agave hemp (*Americana*)	0.008
Wool	0.010
Banana fibre	0.019
Sisal hemp	0.022
Agave hemp (*Fourcroydes*)	0.027
Viscose rayon	0.025
Agave hemp (*Fourcroydes*)	0.027
Nitrate rayon	0.030
Cotton	0.047
Silk	0.057
Italian hemp	0.065
Flax	0.067

In this table the differences between several types of hemp of similar appearance are clearly shown.

As further instance of the value of this specific index of birefringence, consider the observed variation of this figure with the lignin content of the fibre. For ramie the lignin content is approximately 1.5% and the index is 0.07. For hemp of 5.4% lignin content the index is 0.055. For jute with a lignin content of 40.0% the index is 0.041. It is also very probable that refractive index determinations will provide a relatively simple means for determining the degree of mercerization of fibres.

Fibre Quality Determination:—A second use of polarized light is for the purpose of determining fibre quality. In general, the higher the double refraction of the fibre, the stronger and more elastic the fibre is found to be. Further, the colors produced in polarized light, properly applied to cotton fibre, allow rapid and precise grading of the fibre for maturity. The tangles of immature cotton found in yarn and fabric (the mill man calls

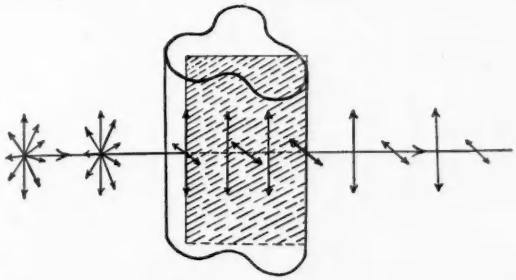


FIG. 9b. Polarizing action of rayon filament on a ray of light.

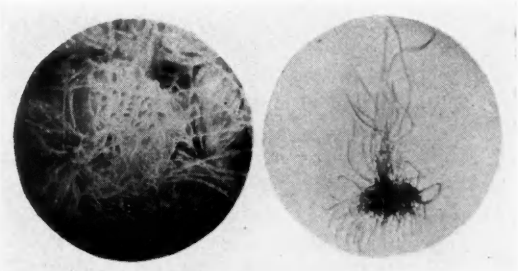


FIG. 10. (*Left*) Nep on cotton fabric. (*Right*) Nep removed from cotton fabric. The fibres are almost 100% immature.

FIG. 11. Cross-sections of mature and immature cotton fibres as selected by their respective colors with a polarizing microscope.

them *neps*) are the cause of uneven dyeing, fuzzy yarns, poor mercerization and finishing and excessive waste in processing. Now cotton containing not more than a minimum allowable percentage of immature fibre can be purchased, and bales containing more than an acceptable amount can be rejected prior to processing. The technique has already seen use in a few mills and will soon be extended to others. It is the direct result of application made available by fundamental research conducted without thought of a possible immediate industrial usage.

Micro-Structure of Fibres:—A third application is to be found in the investigation of the micro-structure of fibres. By means of polarized light, evidence of the existence of details of structure too small ever to be seen directly with even the most powerful microscope can be found. When these observations are correlated with those made by means of ultra violet excited fluorescence analysis, and by x-ray diffraction analyses, a satisfactory working hypothesis as to ultimate fibre structure will be evolved.

Using such means it is soon found that fibres have a certain "lining up" of extraordinarily minute structure parallel to or at certain angles with the fibre axis. The scientist notes that when the "lining up" is most nearly parallel, the fibre is strong, elastic and brittle. He sees that when the "lining up" is imperfect, the fibre is weak, plastic and soft. He begins to grade the various fibres and puts asbestos and ramie among those of the former type, and rayon and wool among those of the latter. He sees that ramie, for example, is inherently weak in torsion and bending, and that no method of preparation of the fibre, whatever its cheapness or expense, can change this without altering the fundamental properties of the material. But due to the very molecular perfection of structure he recognizes a splendid fibre with which to work in the laboratory to discover the secrets of fibre structure.

Structurally Simple Fibres For Research

If it was desired to study the effects of changes in adjustment of a loom, and variation in the treatment of warp and filling yarns, the simplest fabric construction possible and the simplest type of loom would be used. To attempt such a study

on a lappett, swivel, leno or jacquard machine would be to invite difficulties due to the complexities of mechanism and fabric structure. A simple loom and a plain weave would be chosen.

Thus for the purpose of working out scientific means of attack on fibre structure problems, as simple a fibre structure as possible should be selected. For vegetable fibres such a one

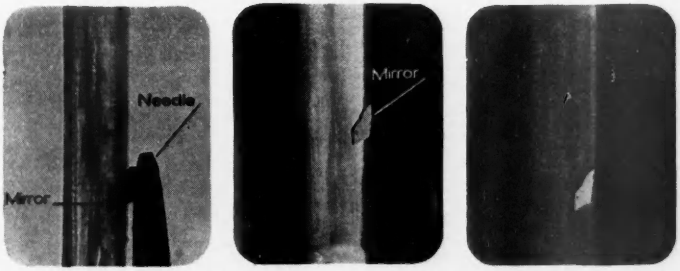


FIG. 12. Polarized fluorescence shows the "lining up" of molecules in fibres. Readings are taken when the fibre and "mirror" match as in center picture. Ultraviolet light must be used.

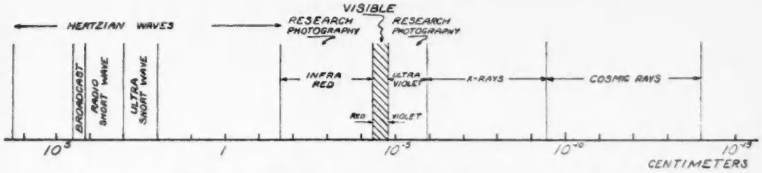


FIG. 13. Only the shaded portion of the energy spectrum is ordinarily used. In the work described here, the portion to the right including ultraviolet and X-rays was employed.

is ramie; for animal fibres, wool or mohair kemp. In both cases the ultimate fibre is large compared with others of its group, and it is simple in its structural arrangement of cells, etc. Much of the work in the fields of micro analysis, fluorescence and x-ray diffraction have therefore been carried out on ramie, and many of the valuable techniques of microscopy have been developed by studying kemp.

There are here fewer bothersome variables with which to contend while details of technique and interpretation of observations are worked out.

" Lining up " by Stretch Spinning

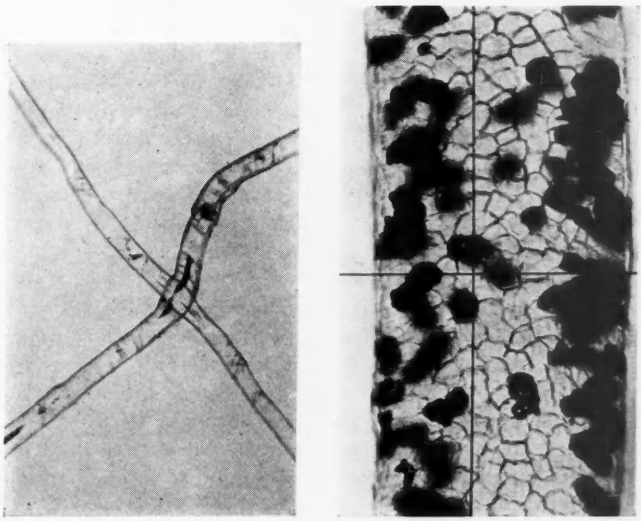
Having perfected technique, the researcher sees that if the "lining up" of rayon (he calls it "molecular orientation") could be made more nearly perfect, the filament would be stronger and more elastic. Day by day he literally as well as figuratively throws new light on the nature of this "lining up." He fastens fluorescing molecules of dyestuff onto the molecules of fibre and causes them to shine brightly in ultra violet light. From analysis of the resulting light he finds out how the molecules must have been arranged. He calls this work in one case the determination of the relative degree of dichroism in polarized light, and, in the other, he calls it a study of micellar orientation by means of polarized fluorescence. Like the proverbial Greek, he has a word for everything. But the textile technologist (acting as interpreter) says to you, "If you want to improve your rayon, then you must improve the perfection of *lining up* of its ultimate structure, the long-chain molecules." To the textile man, long accustomed to obtaining better parallelism by the familiar drafting operation, this is not a particularly difficult thing to do. The rayon technician immediately says: "Aha, let's *stretch spin* our rayon": And in this direction much of the future of the rayon industry lies. This is a result of properly interpreted fundamental research, followed by applied research to make possible an industrial application of tremendous consequence.

The silk worm when it builds its temporary lodging in the form of a cocoon orients the molecules in its filaments somehow. The physiologist, the biologist, the physicist and the chemist are uniting forces to find out how. Can we hope to make as good a fibre as the humble worm? The answer is, "Not until the scientist gets the opportunity and the funds to find out what the worm does chemically and physically. Not until (and this is important), not until his findings are made understandable to the textile man who must manufacture the filaments.

Natural Fibres Unduplicated

It is supposed by many that synthetic fibres can be built up easily by the chemist to duplicate natural fibres. Even when

the resultant fibre has been intended for a substitute or a component of a blend rather than a duplication, the idea of duplication has too frequently persisted. So there arose the term "artificial silk" for a filament which did not even closely approximate either the chemical or physical structure of silk. Thus, more recently, has arisen the term "synthetic wool" and



RAMIE WOOL KEMP

FIG. 14. The simplest vegetable and animal fibres from the standpoint of structure were selected for use in working out details of apparatus and technique. Fortunately both fibres are also relatively large in diameter and hence are easily handled.

"casein wool" for filaments which have practically no resemblance to wool. It is true that in this latter instance an attempt was made to duplicate the chemical composition of wool by including in the new fibre the same amounts of the same elements found in wool.

Because the same amounts of the same chemical elements are used is no reason for the fibre structure and properties to be duplicated. The pieces of a picture puzzle can be assembled

TABLE II

Chemical Constituents, (%)

Elements	Natural Wool	"Synthetic Wool"
Carbon	49.25	53.00
Hydrogen	7.57	7.00
Oxygen	23.66	23.00
Nitrogen	15.86	15.50
Sulphur	3.66	0.70
Phosphorus	——	0.80

in only one way to produce the desired picture. Exactly the same pieces put together any other way produce an entirely different result. Similarly the same number and kind of atoms which, in one scheme of assembly give wool, will in another give an entirely different substance. Thus, while the synthetic wool is dyed with the same dyes as natural wool, it is colored to a deeper shade, does not felt, is seriously weakened by wetting, has lower strength dry, and has far less stretch.

At this point someone is sure to say: "Oh, but this fibre was made from milk, why should it behave like wool? Why not dissolve wool itself and force the solution through a spinnaret to obtain a fibre which would have the same properties as wool but be of any desired length?" All economic objections aside, this process would be quite analogous to taking a sirloin steak, grinding it up fine in a meat chopper (since dissolving anything is simply breaking it down into small enough units to mingle intimately with the solvent) and making up a meat cake of the same size and shape as the original piece. Nobody would accept this "hamburg patty" for the original sirloin steak, however cleverly it might have been broiled. And nobody would welcome the task of restoring the atoms of the hamburg to the same positions and relative relationships which existed in the original meat. Again, it may be true that a bouillion cube contains as much nourishment as a certain piece of chicken, but nobody in his senses would claim that they were the same.

There can be no quarrel with one who produces a satisfactory substitute for something. Many such substitutes exist. But to designate a substance as a *synthetic* something infers a duplication of substance with all of its characteristic properties.

To synthesize (build up) so complex a structure as cotton or wool by simply squirting a solution through a spinnaret is

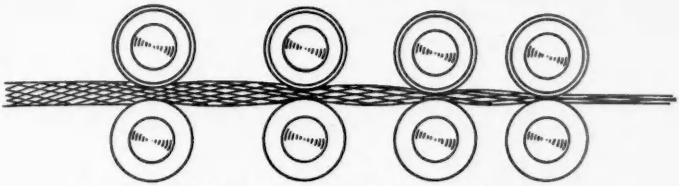


FIG. 15. Attaining parallelism of fibre by roller drafting.

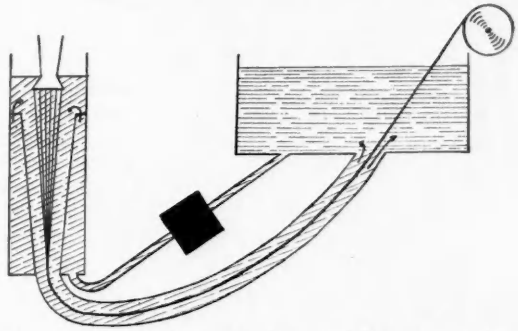


FIG. 16. Attaining better molecular parallelism by stretch spinning rayon.

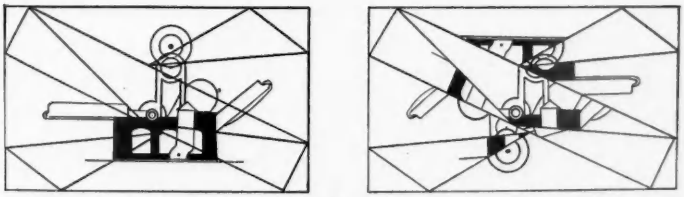


FIG. 17. Picture puzzle of cotton picker. The pieces must be put together properly or there is no picture.

FIG. 18. Wool from milk? The sheep need not worry until the physical arrangement of the atoms is made the same.

like building up a Radio City by pouring the correct quantities of iron, steel, timber, cement, sand, stone, etc., into a gigantic mixer and expecting to pour out a finished building. *Time is necessary.* Wool fibre is not produced at the rate of many feet per second. Cotton fibre does not complete its growth in

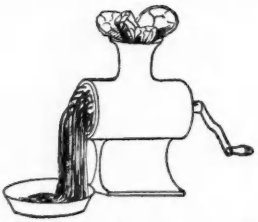


FIG. 19. Sirloin steak ground up into hamburg is still made up of the same atoms.

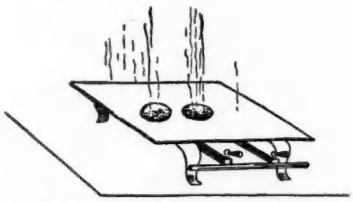


FIG. 20. Hamburg patties are good on occasion—but nobody will mistake them for a broiled sirloin steak.

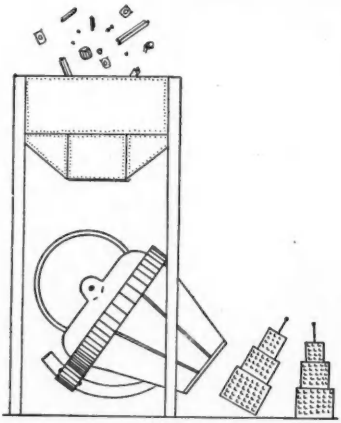


FIG. 21. Skyscrapers are not built by pouring the steel, cement, stone, and wood into a giant concrete mixer and dumping out the finished building. The natural fibres cannot be duplicated by forcing a random mixture of molecules through a spinnerette.

a matter of minutes. *Skill is required.* Human skill of many specialized craftsmen in the case of a Radio City must be employed; natural specialized functions of many cells, glands and nerves in the case of fibres.

Research Analyst or Synthesist

The research worker has two fields of endeavor, depending upon whether he wishes to be analyst or synthesist. If analyst, he is in the position of the archeologist who takes apart an ancient structure to learn of the substances and methods which were necessary to put it together. The investigator of fibre structure with the microscope may be like the building wrecker who can dissect the gross elements of a building and measure the size, nature and placement of the beams, columns, floors, walls, piping systems, wiring, etc. He may use the x-ray analysis and more nearly resemble the laboratory technician who determines by analysis the structure of the steel, the kind of wood, the composition of brick and tile or stone. The former works with large structural units; the latter with their smallest components. In any case he is tearing apart a finished structure.

If synthesist, he is either like an artist who, given paints, brushes and canvas, can combine pigment with fabric to produce a masterpiece; or he is like a two-year-old child with the same materials who creates a first class "daub." What does the two-year-old lack that the great master possesses? The answer is: skill, vision and knowledge. No masterpiece was ever painted blindfold. At our present state of skill and knowledge we resemble more nearly the two-year-old, and nature more nearly resembles the artist. But, as Dr. Bush comments: "Considering the fact that he has been at it for only a few thousand years, man makes rather good textiles. Compared to nature, however, he is still an amateur with much to learn. Of course nature has carried on its development over some hundreds of thousands of years and man cannot wait that long. Fortunately he does not have to. He can accomplish in a decade results which would require hundreds of years by empirical methods or thousands of years by processes of evolution or natural selection. This he can do in only one way: by research, intelligent and intensive research, vigorously supported and patiently followed up in production."

(*To be concluded*)

(*Continued from P. 270.*)

Dr. B. F. Brown, dean of the Economics Department of N. C. State College, led a discussion on the teaching of textile economics. At that session, the meeting also explored the possibility of conducting a 10-day seminar in New York for the men from the economics department who would handle the economics text. The proposal was received most favorably by all present, and has been referred to the directors of the Foundation for consideration. Another important project undertaken by this group—that of the development of the technical texts for the teaching of production methods—was reported on by H. H. Willlis, dean of the textile school of Clemson College.

The success of the conference was largely due to the active participation of the textile school deans in the discussion. Those in attendance were: E. W. France, Philadelphia Textile School; Chas. H. Eames, Lowell Textile Institute; Henry W. Nichols, Bradford Durfee Textile School; George Walker, New Bedford Textile School; W. D. Fales, Rhode Island School of Design; Thomas Nelson, North Carolina State College; H. H. Willis, Clemson College; C. A. Jones, A. French Textile School, Georgia School of Technology; E. W. Camp, Alabama Polytechnic Institute; J. B. Bagley, Texas Textile School; and M. E. Heard, Texas Technological College. Col. John W. Harrelson, Dean of Administration, North Carolina State College, was a guest of the conference.

International Contacts Desired

THE American Association of Textile Technologists, whose membership is at present largely confined to persons engaged in commercial and mill testing of textiles, is desirous, according to Pres. Harry Levine, of establishing contacts with similar groups in foreign textile countries. The objectives would be mutual exchange of information concerning test methods, standards, and interpretation of testing data and results for all textile materials from the raw to the finished state; also the possible formation of an international association of textile technologists with conferences annually. Mr. Levine may be addressed at 22 West 26th St., New York, N. Y., U. S. A.

* * *

"*IT is axiomatic in the world of today which is equipped to produce so much more of everything than mankind is able under existing conditions to buy and absorb, that producers who are not prepared to set aside adequate funds for research work will lose markets to competitors who do.*" Anglo-Oriental Mining Corp., Ltd.

Moisture Adsorption in Cotton and Other Fibrous Insulating Materials: A Proposed Explanation

ALBERT C. WALKER *

(*Continued from Vol. VII, No. 6*)

G.—Reduction in Moisture Adsorption of Cotton by Acetylation

New [28] has shown that the equilibrium moisture content of cotton is progressively reduced as the acetyl content is increased. Below 21% CH_3CO content, acetylation can be carried out in a mild way without appreciable effect upon the strength or physical structure of the hair. Above this value the fibre appears to be increasingly attacked by the acetylating mixture. Moisture adsorption isotherms for cotton containing different percentages of CH_3CO have been obtained by two investigators, New [26] and Storks.† Fig. 5 shows portions of these adsorption isotherms at two humidities (20% and 40%), sufficient to give on extrapolation, monomolecular layer intercepts similar to that of Fig. 4. With increasing acetyl content, the intercepts are at progressively lower moisture contents, until at 21% or greater, the extrapolated values are zero.

Considering the structure postulated in Fig. 1, it might be expected that a larger proportion of surface hydroxyls would be acetylated than the average at any given acetyl content. The fact that the intercept is zero for acetyl contents in excess of 21% suggests that all surface hydroxyls have been converted to acetate and no longer adsorb moisture. A consequence of this hypothesis is that the slope of the curve should approach zero with increasing acetyl content and become zero above 21% CH_3CO. Obviously this is not the case, for the material is still hygroscopic, but it is interesting to speculate as to just what change may have taken place on the surfaces.

If such partially acetylated cotton has all cellulose molecules in the fibril surfaces converted to the triacetate, and the remaining cellulose structure to the monoacetate, it is conceivable that the cohesive forces originally binding the fibril surface cellulose molecules to those directly beneath them have been so diminished in strength that water molecules can now adsorb upon the *available* hydroxyls in this second layer.‡ There are two reasons why there may be a smaller number of available hydroxyls on this second layer than in the surface before acetylation:

* Bell Telephone Laboratories, New York, N. Y.

† Unpublished data obtained by Mr. K. H. Storks, at the Bell Telephone Laboratories.

‡ It seems obvious that moisture can penetrate into all parts of the cellulose structure, but the present discussion is on the question of where the water molecules will be held by unbalanced surface forces.

(1) Molecules in this second layer have been converted to monoacetate so that only two-thirds as many hydroxyls are available here as in the original surface.

(2) On those fibril surfaces parallel to the b-c plane of the unit cell (Fig. 3) there will be but one-third as many hydroxyls available as on the original surface, since it is unlikely that the cellobiose molecules in this layer are oriented as was assumed for the surface layer.

The net total moisture which may adsorb on this second layer is therefore only one-half that estimated for the fibril surfaces of untreated cotton. Furthermore, it is assumed that all surface hydroxyls within the fibrils have been acetylated.

At 20% R.H. untreated cotton adsorbs 2.83% M.C. (Table 2). Subtracting from this, 0.8%, for moisture adsorbed within the fibrils, leaves 2.03% for fibril surfaces. Since cotton containing more than 21% acetyl is assumed to take up but half this amount on the second layer, the total moisture adsorption for the acetylated cotton is about 1%. The observed value is 0.9%. Similarly, at 40% R.H. the estimated value is 1.85%, and that observed is 1.80%.

At low acetyl contents it is unlikely that a sufficient number of fibril surface molecules are converted to triacetate, under the mild acetylation conditions, to materially affect the cohesive forces binding first and second layer molecules together. The moisture adsorption under these conditions is considered as being reduced just in proportion to the reduction in available hydroxyls on all internal surfaces, in accordance with the following ratio:

$$\frac{21.3 - \%\ \text{acetyl}}{21.3}$$

where 21.3 is the acetyl content corresponding to the monoacetate state.

Applying this ratio to Storks' data (Fig. 5-a) the 2.91% acetyl material should have only 86% as many free surface hydroxyls as the untreated cotton. At 20% R.H. the moisture content of untreated cotton is

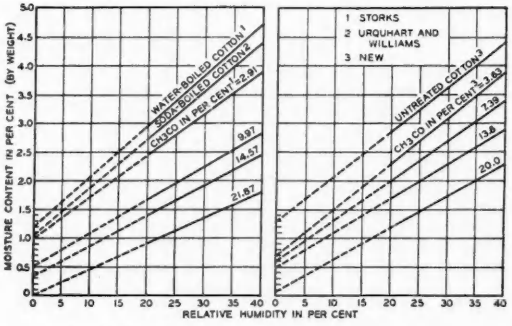


FIG. 5. Extrapolated Moisture Content Intercepts from Adsorption Isotherms for Untreated Cotton and Acetylated Cotton. Left—Data on acetylated cotton by K. H. Storks. Right—Data on acetylated cotton by A. A. New.

2.83%. Of this, 86% is 2.44% M.C., which checks the 20% R.H. point for the 2.91% acetyl cotton. At 40% R.H. the observed value is 3.89%; that calculated is 3.87%.

These and similarly calculated values for other acetyl contents for both Storks' and New's data are given in Table 2. The deviations between observed and calculated values increase with increasing acetyl content indicating that more and more of the surface cellulose molecules become completely converted to triacetate so that the second layer hydroxyls progressively adsorb more moisture.

TABLE 2

Observed and Calculated Equilibrium Moisture Contents for Acetylated Cottons

% CH_3CO	Ratio	Percentage Moisture Content at				Monomolecular Intercept	
		20% R.H.		40% R.H.			
		Observed	Calculated	Observed	Calculated	Observed	Calculated
0% (a)		2.95		4.71		1.18	1.17 *
0% (b)		2.85		4.4		1.3	1.17
0% (c)		2.70		4.4		1.04	1.17
Averages		2.83		4.50		1.17	1.17
2.91 (a)	86%	2.44	2.44	3.89	3.87	1.0	1.0
9.97 (a)	53	1.66	1.50	2.83	2.38	0.50	0.62
14.57 (a)	32	1.39	0.91	2.46	1.44	0.35	0.37
21.87 (a)	0	0.90	0	1.80	0	0	0
3.63 (b)	83%	2.3	2.35	3.9	3.7	0.7	0.97
7.39 (b)	65	2.0	1.8	3.4	2.9	0.62	0.76
13.6 (b)	36	1.7	1.0	2.9	1.6	0.50	0.42
20.0 (b)	6	1.2	0.2	2.3	0.3	0.10	0.07

(a) Data by K. H. Storks. (b) Data by A. A. New.[26] (c) Urquhart and Williams.[14]
* These calculated intercepts for untreated cotton are the sum of quantities computed in Sections A and B using an average value of 0.75% for moisture on surface within fibrils.

H.—Total Moisture Required to Fill the Pits and Lumen

From Fig. 1-a, it appears that cotton may hold considerably more moisture than corresponds to the saturation values calculated under E. A layer of moisture 35 molecules thick on the fibril surfaces facing the pits would extend outwards into the pits a distance of a little over 200 AU from each side, or a total of 400 AU. When dry, these idealized pits are represented as triangles having an altitude of 42750 AU and a base width (entrance to pit) of 2680 AU. At saturation this altitude increases to 56600 AU, and the entrance or base of the triangle to 3550 AU. When filled with water this larger triangle will contain:

$$56600 \times \frac{3550}{2} \times 10.3 \times 10^{-24} \times 0.997 = 10.25 \times 10^{-16} \text{ grams}$$

per unit cell length along the fibril axis, assuming the density of liquid water as 0.997 at 25° C. This amount of water is associated with 1/100 the total weight of cellulose in the hair cross-section per unit cell depth or:

$$\frac{150 \times 2 \times 165 \times 33 \times 324}{6.06 \times 10^{-3}} = 8.7 \times 10^{-16} \text{ gr.}$$

The percentage moisture required to fill the pit is:

$$(10.25/8.7) \times 100 = 117\%.$$

This includes the previously calculated multimolecular layers on the pit side walls, this being one-half the total fibril surface moisture calculated under D, or $23.8/2 = 12\%$. Therefore, the additional water required to fill the pits over that already calculated from swelling data is: $117 - 12 = 105\%$.

In addition, there will be a small amount of water required to fill the central lumen, assuming its volume to be unchanged during the swelling process. Calculated as before, this is 14.2%. The amount already calculated as a multimolecular layer on the inner surface of the fibrils lining the lumen is negligible.

The total moisture thus calculated, which may be retained within the hair structure is: $23.8 + 105 + 14 = 143\%$.

Coward and Spencer [17] have shown that wet cotton retains about 50% of its weight of water after centrifuging, and these authors expressed the opinion that the water was not interstitial, but contained in the hairs themselves. The above calculations indicate that not only 50% but that much more than 100% moisture may be retained in the cotton hair, and the amount retained after centrifuging or pressing may be some function of the treatment and the surface energy relations of the adsorbed moisture.

Electrical Properties

In a previous paper [1] a series of simple equations were advanced to show the relation between moisture content, relative humidity, and the electrical insulation resistance of cotton:

$$\log \text{Ins. Res.} = -A(\%\ \text{M.C.}) + B \quad (1)$$
$$\log \text{Ins. Res.} = -A(\log\ \%\ \text{M.C.}) + B \quad (2)$$
$$\log \text{Ins. Res.} = -A(\%\ \text{R.H.}) + B \quad (3)$$

Equation 1 was considered as applying for moisture contents below 3%, Equation 2 for values between 3% and 10%, and Equation 3 between 10% moisture content and saturation.

Since the resistivity of cotton becomes enormously high as the moisture content approaches zero, it has been difficult to extend the study of these relations much below 3% M.C. However, a recent study along somewhat different lines has provided us with information on this relation down to as low as 0.04% M.C. These data are on paper made from a pure form of cellulose, and are given in Fig. 6. It will be seen that between 1% and 6% M.C. the curve is linear,* conforming to Equation 1,

* The slope A is about 0.7 in contrast to 1.06 obtained previously for cotton. This difference may be due to the fact that current flow in the paper measurements was transversely through the sheet, not along the fibre length as was the case for the cotton measurements.

but below this point the resistivity increases much more rapidly with decreasing moisture content than is required by (1). If the linear portion of this curve is extrapolated to the I.R. axis, the resistance at this intercept corresponds to a moisture content of 0.35%, being of the same order of magnitude as that estimated to cover fibril surfaces with a monomolecular layer, suggesting that the linear portion of the curve is specifically related to moisture sorption on the fibril surfaces.

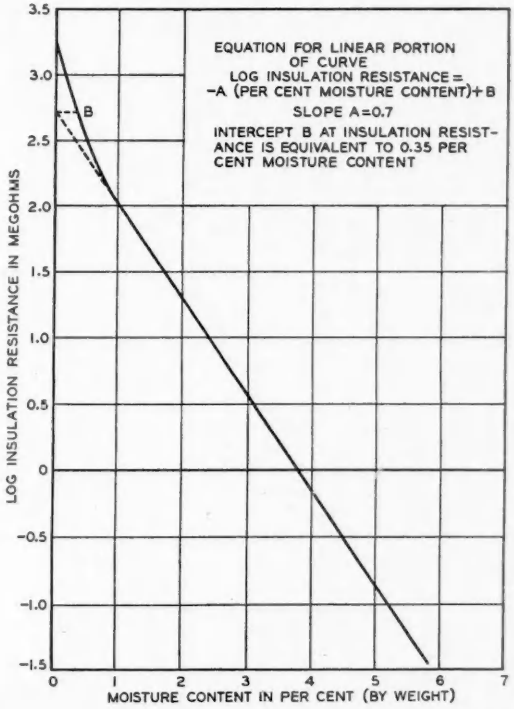


FIG. 6. Moisture Content. Insulation Resistance Relation for Rag Paper.

It now appears possible to provide a more comprehensive theory for electrical conduction through the moisture paths in a textile than has been suggested previously.[1, 2]

Below 1% moisture content it is likely that Equation 1 fails to hold, due to obvious discontinuities in the moisture paths over surfaces containing less than a monomolecular layer of water. Above 1% some such non-linear relation as that of Equation 1 should apply, since the space-pattern of the water chains described on page 289 is such that simply in-

creasing the thickness of the water layer will not cause a proportionate decrease in the resistivity. With increasing humidity, the water chains lengthen and possibly the free ends of these chains oscillate over a wider range about their hydroxyl bases and establish more frequent contact with adjacent water chains. Thus the completion of parallel paths of low resisitivity across relatively high resistance cellulose surfaces no doubt will cause much greater decreases in resistivity than is consistent with the percentage increase in moisture content.*

It seems evident from Fig. 2A that small increments of water might be expected sufficiently to lengthen water chains of minimum separation so as to establish contacts between them along the current path, but that larger increments of water are required to accomplish the same result between more widely separated chains. This would explain the gradual change from the relation expressed by Equation 1 at low moisture contents to Equation 2 at intermediate moisture contents.

At some point along the humidity curve it is conceivable that capillary condensation occurs in the pits so that at progressively higher humidities the increasing cross-section of these pits plays a more important part in current conduction than the adsorbed chains of water molecules. This may explain why Equation 3 is found to apply at higher humidities.

Adsorption, however, appears to continue throughout the whole of the humidity range, consistent with the hair swelling relations previously discussed. Thus it is shown that adsorption and capillary condensation need not be considered separately but may go along together with a gradual shifting in the importance from one to the other in the current conduction process.

Evershed [28] explained the decrease in resistivity of a textile with increasing applied potential as being due to elongation of pools of water in the material under electrical stress forming more continuous current paths. This deviation from Ohm's law may be explained also as being due to the influence of increasing electrical stress upon the oscillating movement of the free ends of moisture chains, bringing more of them into orderly alignment along the line of applied potential, so as to establish shorter current paths through the structure.

The difference in electrical behavior of different textile fibres may be illustrated by a comparison of the adsorption of moisture on cotton and silk surfaces. From Astbury's pictures of the structure of protein molecules as compared with cellulose molecules it appears that although there are more points per unit surface for moisture to condense upon the protein surface, there are also possibilities of separation of adjacent moisture chains in a manner similar to that discussed for cellulose; and, furthermore, there appear to be side chains of hydrocarbons interspersed in the protein chain which may act as barriers to the ready contact of adsorbed water chains on either side of these hydrocarbon chains. Consequently, silk might be expected to have a higher resistance for a given moisture content than cotton, but also silk has possible barriers in the current path which might increase its resistance to dielectric breakdown under high potential stress.

* This is considered a more specific explanation than that suggested by Murphy and Walker,[2] of alternately expanded and constricted sections along the conducting paths, forming a regular space-pattern whose elements have different dimensions for different textiles.

Change of Conduction Component of Power Factor with Moisture Content

Whitehead,[29] in a study of the effects of moisture on power cable paper insulation, obtained data on the change of power factor with increasing moisture content. Fig. 7 shows this relation. It will be noted that the conduction component (tan ψi) of the power factor rises sharply as the

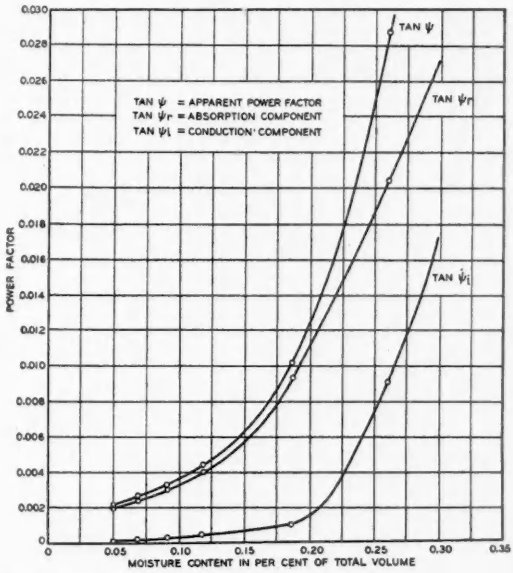


FIG. 7. Variation of Power Factor Components with Residual Moisture Content. Whitehead.[29]

moisture content of the paper exceeds 0.2% by volume (about 0.3% by weight). This increase occurs in the range consistent with the completion of the monomolecular layer of moisture on the internal surface of the material, particularly since the internal surface of paper and cotton appears to be of the same order of magnitude.*

* The total internal surface of cotton is estimated from the assumed cubic geometry given in this paper as about 1×10^6 cm²/gram. If calculated from the size of the water molecule and the intercept moisture content on Fig. 4, it is about 6×10^5 cm²/gram. The monomolecular layer discussed here does not include all available surface, but only enough of the surface to satisfy all of the hydroxyl groups with water molecules.

Salley [30] estimates the internal surface of wood pulp from moisture adsorption data as 1.6 to 1.8×10^6 cm²/gram. It seems likely that wood pulp, being chemically treated, might have more internal surface than the cotton hair.

Behavior of Cotton at Low Moisture Contents

Peirce[31] proposed a two-phase theory for the sorption of moisture by cotton, and he attempted to explain the following properties of the material on this basis. He states: "It is known that a small quantity of water is adsorbed by dry cotton very much more rapidly than the same amount added to cotton with a moderate water content, has much greater effect on the elastic properties, evolves more heat and is more difficult to remove. The effect appears simplified if the adsorbed water be regarded in two distinct phases, one in which the water adds to the hexose group (*a*), the other in indefinite number of molecules adsorbed in a looser fashion over all available surface, limited only by the conditions of space and of equilibrium with the external concentration of aqueous vapor (*b*)."

The differentiation secured by fibril and other internal surface is considered as giving a more definite explanation of such two-phase adsorption than that proposed by Peirce, in that the (*a*) phase is concerned with adding moisture to specific active points on the surface hexose groups, where such surface is readily available for moisture adsorption, and the (*b*) phase, also with a definite number of active points of surface within the body of the fibrils, much less accessible than those in the fibril surface.

According to the cotton hair structure presented in this paper, there is actually more than twice as much internal surface available for moisture adsorption from the dry state than for the adsorption of an equal amount of water on cotton already in equilibrium with more than 1% moisture content.*

First layer water adsorption on cellulose surfaces might be expected to evolve more heat than subsequent layers since the interaction is between water and cellulose hydroxyls, not between water and water as in subsequent layers. The elasticity of cotton should be critically dependent upon the initial molecular layer of moisture, since only one layer would appear to be necessary as a lubricant. Also water held within the fibril structure no doubt is the most difficult to remove, since it must diffuse out through the fibril structure.

It is well known that dense cellulose materials, such as wood or fibre board, require slow drying. Warping and cracking may be serious below 2% moisture content. Under such conditions it is difficult to prevent the outer layers from becoming "bone dry." If the moisture in these layers is reduced to less than that equivalent to a monomolecular layer on the internal surface, hydroxyl groups on the contiguous surfaces may attract each other with sufficient force so that when moisture is again taken up it will not separate these surfaces, but will cause uneven swelling and warping. That something of the sort occurs is indicated by published data on cotton[1] and on fabrics.[32] A fabric dried by contact with a steam heated drum, without pressure ("can" drying) has a harsh feel and is fairly stiff as compared with hot air drying. Furthermore, if a fabric is damp-

* No doubt some moisture which eventually reaches the surface within the fibrils requires considerable time to diffuse through the fibril structure, but it seems reasonable to conceive that part of this moisture may be adsorbed into the fibrils with sufficient speed to account for the increased rapidity of adsorption of the initial moisture on dry cotton.

The slow diffusion of some moisture to those surfaces most deeply buried in the fibrils, may account for the fact that cotton very nearly reaches equilibrium with any given humidity in a relatively few minutes, but the final establishment of equilibrium conditions, involving a change of less than 1% of moisture, may take more than 24 hours.

ened to too great an extent before calendering (drying under both heat and pressure) it is apt to be thin and have a crisp, papery feel. This may be partially removed by swelling the fibres again through wetting, but it is said to produce a permanently undesirable effect. It is conceivable that some internal surface can be more or less permanently closed to moisture, and that the material loses elasticity and becomes harsh because of a lack of a lubricating moisture film between fibril surfaces.

Tentative Conclusions

While it is not the purpose of this paper to present conclusive evidence for a cotton hair structure of the specific type described, the calculated data are in such close agreement with many experimental facts that it seems reasonable to set forth a few tentative conclusions for the discussion, as follows:

1.—The moisture content necessary to form a monomolecular layer on all internal surface of the cotton hair appears to be slightly more than 1% of the hair weight.

2.—There appear to be at least two specific kinds of internal surface in fibrous cellulose upon which moisture may be adsorbed.

3.—Less than half the internal surface, that termed fibril surface, is considered to be involved in moisture adsorption which causes appreciable transverse swelling of the cotton hair. Upon this surface multimolecular layers of water are assumed to condense, the thickness of such layers increasing progressively up to saturation with corresponding increases in hair diameter during the whole of this range, and each hydroxyl group in the cellulose surface being the base of a water chain, with separations between these chains corresponding to the arrangement of the hydroxyl groups on the cellulose surface.

4.—Moisture adsorbed on the remaining internal surface does not appear to be involved in transverse swelling, but may be responsible for the slight longitudinal swelling exhibited by cotton. To account for the amount of water required to form a monomolecular layer on this additional internal surface it is assumed that this surface is within the body of the fibrils, and is located on ends of crystallites. To account for the slight swelling, it is assumed that only a monomolecular layer can be adsorbed on these surfaces.

5.—A theory is proposed to explain the dependence of the electrical properties of textiles upon their moisture adsorbing properties, and upon the surface distribution of moisture within the submicroscopic structure.

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Abstracts

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I. Fibres (Synthetic and Natural) and Fibre Analysis

Absorption Edges in the X-ray Patterns of Native and Mercerized Cellulose. W. A. Sisson, G. L. Clark and E. A. Parker. *J. Am. Chem. Soc.*, Sept. 1936, P. 1635–8.

Some of the values obtained by Clark and others, which were previously attributed to micellar dimensions, are now shown to originate from bromine and silver absorption edges in the photographic emulsion, and consequently cannot be associated with the magnitude of the micelle. (From *Eastman Kodak Abs. Bull.*, Dec. 1936, P. 545.) (S)

Commercial Weight of Textile Fibres. C. H. Fischer. *Monats. für Textil-Ind.*, July 1936, P. 174–7; *Cotton Literature*, Dec. 1936, P. 467. (C)

Cotine Fibre: Production and Properties. Cotine Products Ltd. and G. J. de Fleury. *Text. Merc. & Argus.*, 1936, V. 95, P. 168.

"Cotine" is said to be a bast fibre obtained from an annual plant yielding about 800–1000 lb. per acre and definitely distinct from flax, hemp, Indian hemp, jute, roselle or ramie fibre. The ultimate fibres resemble cotton in staple length and fineness. (From *J. T. I.*, Oct. 1936, P. A452.) (C)

II. Yarns and Fabrics

Air Permeability of Fabrics: Study on the. S. Saito and H. Utida. *J. Soc. Tex. Ind., Japan,* 1936, P. 247; *Rayon Tex. Mo.,* Jan. 1937, P. 105. (C)

Cloth Drying: Requirements Which Govern Expense. Reginald Trautschold. *Rayon Tex. Mo.,* Mar. 1937, P. 73–5. (C)

Contraction in Twisted Viscose Yarns. Anon. *Am. W. & C. Rptr.,* Feb. 18, 1937, P. 7–8, 31.

A series of tests with special apparatus indicate inaccuracies in the contraction tables commonly used by throwsters. The article contains a chart showing the percentage of contraction for any of the ordinary yarn deniers and any particular turns per inch desired. (C)

Cotton Yarn: Relation Between Fibre Length and Yarn Twist Affecting the Strength of. K. Huzino. *J. Soc. Tex. Ind., Japan,* 1936, P. 363; *Rayon Tex. Mo.,* Jan. 1937, P. 104. (C)

Fabrics: Permeability to Dust. E. W. Chuehrina. *Arch. Hyg. u. Bakt.,* 1936, V. 115, P. 250–6 (through *Textilber.,* 1936, V. 17, P. 596).

Quantitative tests of the permeability of clothing materials to dust are obtained by means of a device in which air of constant dust content is sucked through a sample of the fabric and its dust content on each side of the fabric determined. For this purpose the dust is precipitated by means of an electric discharge and measured photometrically. This measurement is very simple when methylene blue dust is used. The disadvantages of this method and the variations between its results and those of actual wear tests are discussed. (From *J. T. I.,* Oct. 1936, P. A493.) (C)

Finishers Show Results. John Bancroft, Jr. *Daily News Record,* Textile Research Issue, Jan. 21, 1937, P. 42.

Refers to fast colors, and also to several recent results of finishing research, such as air-conditioning, new type glazes and permanent finishes. (C)

Finishing: Far-reaching Progress in. J. A. Goldthwait. *Daily News Record,* Textile Research Issue, Jan. 21, 1937, P. 16. (C)

Mildew in Cotton Goods: Improved Methods for Examining Mildewed Materials. *Tex. Col.,* Nov. 1936, P. 774–5 (reprint from *Textile Mercury and Argus*). (C)

Mildew on Cotton: Examination of. Wm. G. Chace. *Am. Dye. Rptr.,* Dec. 14, 1936, P. 716.

The test was carried out as follows: The sample is warmed in lactophenol on the slide one minute. It is then transferred to a 1% aqueous solution of Poirier's Blue (National Aniline and Chemical Co.'s stain) and warmed three minutes. It is then washed in water and warmed in lacto-

phenol to remove as much color as possible. The sample may be examined immediately in lacto-phenol or dried and mounted in thick Canada balsam. The cotton is only slightly colored, the mold is stained a deep blue. (C)

MILLS' EFFICIENCY UP 27% IN 25 YEARS. Russell T. Fisher. *Daily News Record,* Textile Research Issue, Jan. 21, 1937, P. 40.

The author credits increased productivity of cotton textile industry largely to research. (C)

MOTHPROOFING: SURVEY OF THE PROGRESS IN—DURING 1928–36. C. O. Clark. *J. T. I.,* Dec. 1936, P. P389–P394.

Article includes a very complete bibliography. (C)

PERMEABILITY TO MOISTURE OF SYNTHETIC RESIN FINISHES FOR AIRCRAFT. Gordon M. Kline. *B. S. J. Rsch.,* Feb. 1937, P. 235–49. (C)

"PHILBIAIS" FABRIC: PROPERTIES. *Revue Text.,* 1936, V. 34, P. 357–9.

It is shown that Philbiais fabric has greater elasticity and greater resistance to tension, tearing and perforation than ordinary fabrics. In Philbiais fabric the weft threads are inclined at an angle of 45° to the warp threads. The use of this fabric in the construction of flexible rubber delivery pipes is briefly discussed. (From *J. T. I.,* Oct. 1936, P. A467.) (C)

RAYON: CHALLENGE OF—QUICKENS. Fessenden S. Blanchard. *Daily News Record,* Textile Research Issue, Jan. 21, 1937, P. 12.

Spun rayon, which only a few years ago was almost unknown, has already assumed a position where it is exerting an important influence upon a large number of textile markets. A well integrated research program into the use of these new fibres can, undoubtedly, be made to yield results to the firm that is willing to make the investment required. (C)

RAYON CRÊPE: MODIFICATION BY USE OF SPECIAL CRÊPING LIQUORS. *Silk J. Rayon World,* 1936, V. 13, No. 147, P. 32–3.

The facts that untwisting occurs only on wetting, and that viscose rayon is no more elastic when wet than dry, give rise to the theory that the moving force in crêping is not the tendency to untwist but the swelling of the individual fibres which takes place on wetting and which sets up compression only to be relieved by untwisting. Therefore, the addition to the crêping bath of some substance, such as salt or glycerin, which is known to repress swelling of rayon, should result in a smoother crêpe. Experiments are described and results are tabulated which are in support of this view. It is shown to be possible by variations of temperature and composition of the crêping liquor, and adjustments of the subsequent finishing of the crêped fabric, to modify its appearance considerably. Methods of crêping are suggested which have not yet been exploited. (From *J. T. I.,* Nov. 1936, P. A536.) (C)

RAYON CRÊPE YARNS. Ernest Doute. *Canadian Tex. J.,* Mar. 5, 1937, P. 39–40.

Abstract of paper discussing principles controlling soaking, conditioning and winding of rayon yarns for twisting. (C)

III. Chemical and Other Processing (Not Otherwise Classified)

Animal Fibre: Oxidative Dyeing. E. K. Zilberkveit and A. M. Zubin. *J. Appl. Chem. Russ.*, 1936, V. 9, P. 1327–33 (through *Brit. Chem. Abs.*, 1936, B982).

The scleroprotein of the medullary portions of hair is more intensely dyed by *p*-phenylenediamine in the presence of hydrogen peroxide than is the cortical keratin. In the presence of dichromate the reverse is the case. Iron salts promote more intense dyeing of both the medulla and cortex. Only superficial blackening of hair is achieved by immersion in aqueous NaPb thiosulphate in the presence of excess of thiosulphate, as the particles of lead sulphide formed are too large to be able to diffuse freely into the deeper layers. (From *J. T. I.*, Dec. 1936, P. A612.) (C)

Cellulose Solvents and Their Use in Finishing. P. E. Hattinger. *Am. Dye. Rptr.*, Mar. 8, 1937, P. 120–1.

Refers briefly to the newest solvents, some of which have new possibilities. (C)

Chemical Changes Hold Great Future. D. H. Powers. *Daily News Record*, Textile Research Issue, Jan. 21, 1937, P. 28.

Present and possible applications of synthetic resins and cellulose solvents. (C)

Chemical Damage to Fibres Checked. F. H. Guernsey. *Daily News Record*, Textile Research Issue, Jan. 21, 1937, P. 10.

The author holds that the incorporation of cellulose viscosity data in cotton specifications would prove to be a definitive advantage to the manufacturer as well as the consumer. (C)

Chemical Reactions Involved in Chroming, and Their Result. Kurt Bross and W. Wittenberger. *Monats. f. Textil-Ind.*, 1935, V. 50, P. 241; *Am. Dye Rptr.*, Mar. 8, 1937, P. 138. (C)

Chemistry Widens the Textile Market. Walter M. Scott. *Daily News Record*, Textile Research Issue, Jan. 21, 1937, P. 4. (C)

Color and Dyeing Properties of Mono Azo Dyes: Influence of Position Isomerism on the. Wallace R. Brode and Marion E. Griffith. *Am. Dye. Rptr.*, Feb. 22, 1937, P. 90–9.

Paper presented at Saturday afternoon session, Annual Meeting of A. A. T. C. C., Providence, R. I., Dec. 5, 1936. (C)

Color-fastness: New Methods of Improving. Pegasus. *Tex. Col.*, Dec. 1936, P. 822–3; Jan. 1937, P. 45–52. (C)

Textile Assistants: Determination of the Protective Colloid Action of—in the Presence of Calcium and Magnesium Ions. Max Baudoin. *Mell. Textilber.*, 1936, P. 654, 932.

The author is of the opinion that the protective action of all agents which are present chiefly in a molecularly disperse state in an aqueous so-

lution can be improved by the presence of calcium or magnesium ions, provided that the precipitate formed is not deposited mainly in a coarsely disperse form. In that case the protective action depends chiefly upon the concentration of the calcium ions and of the assistant itself, and naturally also upon the temperature and, further, upon the ratio of the speed of the formation of the nucleus to the speed of crystallization of the calcium or magnesium salt produced. If the speed of formation of the nucleus is relatively high in relation to the speed of crystallization, small particles with typically colloidal properties (that is, protective colloids) will chiefly be formed. If the reverse is the case, a few small nuclei will be formed which very rapidly grow larger, leading to flocculation which may cause the Congo Red which is acting as indicator or, generally speaking, the dyestuff in the dyebath to be carried along with it under certain conditions. It follows further that turbidity in itself is not necessarily a measure for the resistance of a textile assistant to the action of calcium and that methods that are based upon the measurement of turbidity must in most cases lead to false conclusions. (C)

TEXTILE CHEMISTRY OF SULFITES. P. E. Hattinger. *Am. Dye. Rptr.*, Nov. 16, 1936, P. 609–12. (C)

TEXTILE PRINTING: EVALUATION OF THICKENING AGENTS FOR. E. von Pezold. *Mell. Textilber.*, 1936, V. 17, P. 222–3, 330–1, 418–20; *C. A.*, 1936, V. 30, Col. 6569. (W)

TITANIUM PIGMENTS. Wm. R. Willets. *Paper Trade J.*, Nov. 19, 1936, P. 43–5.

A review of their properties, their manufacture, and their use in the paper industry. (C)

TOXICOLOGY OF CHROMIUM COMPOUNDS USED IN DYEING. M. Déribéré. *Tiba*, 1936, V. 14, P. 419, 421.

A brief outline of the various Cr compds. used in the dyeing industry and of the precautions to be taken in their use. (From *C. A.*, 1936, V. 30, Col. 7347.) (W)

ULTRA-VIOLET LIGHT IN THE DYEING INDUSTRY. M. Déribéré. *Tiba*, 1935, V. 13, P. 173, 175, 259, 329, 331, 415, 417, 481–5, 547, 549, 607–11, 687–91; *C. A.*, 1936, V. 30, Col. 7348.

A general discussion of the value of ultraviolet light and of its numerous applications in the dyeing industry. (W)

UNION DYEING. C. H. A. Schmitt. *Am. Dye. Rptr.*, Nov. 2, 1936, P. 601–6.

Functions and capabilities of reserve agents when dyeing low grade mixed fabrics. Abstracted from an address delivered at the summer school of the Canadian Association of Textile Colorists and Chemists, Hamilton, Ont., Aug. 17–21, 1936, as printed in *Canadian Tex. J.* (C)

UNSHRINKABLE FINISH ON WOOL MATERIAL. *Am. Dye. Rptr.*, Sept. 7, 1936, P. 493–5 (reprinted from Textile Mercury and Argus). (C)

VAT DYES CONTAINING ONLY CARBON, HYDROGEN AND OXYGEN. R. Fraser Thomson. *J. Soc. Dyers Col.*, 1936, V. 52, P. 247–52; *C. A.*, 1936, V. 30, Col. 6566.

A review of vat dyes contg. only C, H and O, development of which has been consummated since 1900. (W)

VAT DYES: QUALITIES OF INDIGOID AND ANTHRAQUINONE VAT COLORS AND METHODS OF APPLICATION TO ALL TEXTILE FIBRES. T. W. Whattam. *Am. Dye. Rptr.*, Oct. 19, 1936, P. 566–70, 576–8.

WATER-PROOFING TEXTILES. *Tiba*, 1936, P. 179; *Rayon Tex. Mo.*, Nov. 1936, P. 88.

In this and three previous installments, the various methods of water-proofing textiles are reviewed in detail. The methods include treatments with aluminum acetate, paraffin emulsions, soap and metallic salts, combined finishes, oils, tars and various coating compositions. Special reference is made to the production of tarpaulins and similar materials. (C)

WEIGHTING OF SILK. Part II. Franz Weber. *Mell. Textilber.*, 1937 No. 1, P. 96.

The present article discusses the weighting processes in all its phases from a colloid-chemical point of view and calls attention to the connection between familiar working methods and methods of preventing mistakes, which had been found empirically, and the modern colloid-chemical view taken of the processes. The various facts and experiments described provide works chemists with a wealth of material for their guidance in further research in the field of the weighting of silk. (C)

WOOL: EFFECT OF HALOGENS UPON. R. Haller and F. W. Holl. *Mell. Textilber.*, 1936, P. 493; *Rayon Tex. Mo.*, Nov. 1936, P. 88. (C)

WOOL: AN INTERESTING CASE OF CATALYTIC ACTION UPON. A. Molnar. *Monatschr. Textil-Ind.*, 1936, V. 51, P. 158.

The appearance of brownish black stains on wool yarn which had been subjected to the usual washing, bleaching and printing operations was found to be due to the pptn. of Fe from the bleaching app. The Fe was present as hydroxide and sulfide. The stain was not sol. in hot dil. HCl. The brown spots of the wool were "dead," *i.e.*, inelastic, rough and hard like overheated wool, indicating that this damage which can be caused by heating wool to 120° will occur in the presence of Fe at 101–3° owing to catalysis. Expts. carried out by steaming ordinary wool yarns and yarns which had been wetted with regular and complex Fe compds. showed that the untreated yarns were unaffected after one-quarter hour with 0.5 atms. steam while the treated yarn showed a damage already with 0.2 atm. (From *C. A.*, 1936, V. 30, Col. 6203.) (W)

WOOL: NEW VERY FAST ERIOCHROME DYES FOR THE DYEING OF. H. Hoz. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 336–7.

Sp. dyeing directions are given, many new dyes are listed and ten dyed samples are shown. (From *C. A.* 1936, V. 30, Col. 5415.) (W)

YELLOW TONE IN WHITE WOOLENS: UNWANTED. A. J. Hall. *Am. Dye. Rptr.*, Jan. 11, 1937, P. 1–3.

Describes experiments to discover the cause and remedy. (C)

IV. RESEARCH METHODS AND APPARATUS

COTTON HAIRS: NEW METHOD AND APPARATUS FOR DETERMINING AVERAGE LENGTH AND FINENESS OF. Nazir Ahmad and C. Nanjundayya. Indian Central Cotton Committee Technological Laboratory, *Tech. Bull. Series B*, No. 21, July, 1936; *J. T. I.*, Nov. 1936, P. T253–72.

The essential features of the method consist of cutting a representative tuft of fibres, with one end in alignment, into three parts; the first part extending to a known length from the aligned end, the second part also having a known length, and the third part containing fibres of different lengths. The three parts are separately weighed. The average length of the third portion is computed by multiplying the ratio of the weight of the third part to that of the first by the known length of the first part. The average length of the whole tuft is obtained by adding up the individual lengths of the three parts. Furthermore, the fibre-weight per unit length may also be determined by counting the number of fibres in the first section prior to weighing and dividing the weight of the tuft by the number of fibres and the average length. An apparatus, which is designed to carry out the tests accurately and rapidly, is described in this paper. The results of average length determined with the help of this apparatus are compared with those obtained by the older methods, and the agreement is found to be very satisfactory. (C)

COTTON AND A STAPLE FIBRE YARN: COMPARATIVE MECHANICAL-PHYSICAL INVESTIGATIONS WITH A. (German). A. Grote. *Die Kunstseide*, Sept. 1936, P. 355.

The author has carried out a series of physical investigations with a staple yarn and with a cotton yarn for purposes of comparison. The properties which were examined were uniformity of twist, fibre linkage, tensile strength and ultimate breaking extension. Further, the yarns were tested under a load which approached as nearly as possible the mean breaking strength to determine the break during a sustained stress. The methods of carrying out these experiments are described in detail and the article is accompanied by tables and diagrams showing that the staple fibre behaves more favorably than does cotton in fibre linkage, but that its extensibility, which is essential for manipulation, does not yet equal that of cotton. (S)

INSTRUMENTATION STUDIES. I–VIII. *Paper Trade J.*, 1936, Dec. 17, P. 38–43; Dec. 24, P. 32–5; Dec. 31, P. 29–31; 1937, Jan. 7, P. 39–45; Jan. 14, P. 42–7.

Development and adaptation of instruments for the evaluation of smoothness, gloss, and formation. III.—Evaluation of formation by the Thwing Formation Tester; IV.—Correlation of Thwing Formation readings to visual formation gradings by the Mead Standards; V.—Report on gloss; VI.—Modified Oxford Glarimeter; VII.—Comparative study of the Bausch & Lomb Glossmeter and the Ingersoll Glarimeter; VIII.—Analysis of smoothness. (C)